

AN ACCOUNT OF SOME ANOPHELINE MOSQUITOS FOUND IN BRITISH  
NORTH BORNEO, WITH DESCRIPTION OF A NEW SPECIES.

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(MAPS III and IV).

During the course of three years' estate medical work in British North Borneo, ample opportunity was found for studying the local mosquitos, and I publish the few following notes in the hope that they may be of use to other workers in Borneo.

The area of country covered was about 45 miles along the west coast of the Chartered Company's territory between Jesselton and Membakut, roughly between degrees 115° and 116° E. Long., and 5° and 6° N. Lat. The distance from the coast, here known as Kimanis Bay, varied between six and nine miles.

The climate of this part of Borneo is fairly even, and records of temperature taken inside one of the hospitals during the two years 1912-1913 showed it to vary between 74° F. and 84° F. The average yearly rainfall worked out at 94 inches for the past seven years. There is no very prolonged season of wet weather, but the rainfall seems to be distributed evenly throughout the year. A good deal of this part of the coast is swampy with here and there areas of high land, rising in places to hills 50 to 200 feet high. Many of these hills have small streams coursing down them. The jungle for the most part is light and in places has been felled for cultivation of hill rice. Much of this jungle has also been felled by rubber companies in the last five years. The flat land along the 45 miles mentioned is used by natives in places for cultivation of rice and, in a very promiscuous way, sago.

The whole population of this part of Borneo is small and they have suffered much from epidemics of smallpox and cholera. Of the native races those known as Dusuns are the most populous, especially near Papar. In the neighbourhood of any railway station or settlement of Europeans the local population is generally Chinese. The labour on the estates consists mostly of indentured Chinese and Javanese, with a few natives as free labour.

Four rivers enter the sea along this piece of coast, namely, the Papar, Kimanis, Bangawan and Membakut, none of which is of any size, and they are only navigable for quite small craft.

A few isolated mosquitos have been taken from estates along the coast, but by far the majority have been captured or bred from larvae in the neighbourhood of Membakut.

The Membakut village is situated (*see* Map III) practically at the spot where the railway crosses the Membakut river. It stands nearly in the centre of a large area of swamp land extending about six miles north, twelve miles south and six miles west towards the coast. Along this coast there are two types of swamp land, one with large and deep pools, the other with small shallow pools. The latter is the variety met with near Membakut and especially so near the railway along the western side.

A few hundred yards south of Membakut village, close to the railway and on the eastern side of it, are the buildings of Rubber Estate (A), in which many adult Anophe-

lines have been taken. The species that have been found in the houses have in many cases been bred also from larvae taken in the swamp. As can be understood, there was much malaria among the coolies on the estate in spite of prophylactic quinine being taken, their spleen rate being 21·4 per cent.

For an area of about ten miles around Membakut six villages or collections of houses were visited with a view to ascertaining the spleen rate of the children. The ordinary native hut is generally of bamboo on piles 3 to 6 feet high and is dotted anywhere in the neighbourhood of land likely to serve as paddy land, without regard to proximity of swamp or jungle. Among this particular group of villages there was one larger than the rest, known as Kampong Brunei, situated on the banks of the Membakut river, and here in 39 children the spleen rate was found to be 58·9 per cent. In this part of Borneo all the larger villages have been built on the rivers and the natives get their living by fishing and a small amount of rice-growing, the latter almost entirely for their own consumption. The other five villages were practically situated in the large swamp already mentioned and consisted of groups of houses rather widely separated. Sago palm grows everywhere in the neighbourhood and also some of the smaller fruit trees and a few coconut trees. Including Kampong Brunei, I was able to examine 92 children and the spleen rate of this number worked out at 54·3 per cent.

The following table shows the name of the village and the number of children examined in each, with the spleen rate :

Village.	No. of children examined.	Spleen rate.
Membakut, with surrounding villages .. .. .	92	54·3
Bangawan .. .. .	69	1·42
Kimanis .. .. .	52	11·53
Papar (Mill Hill Mission) .. .. .	37	13·5

As a rule, in a village situated on the banks of one of these rivers the health of the natives as regards malaria is good, as will be seen in the case of Kimanis and Bangawan villages. In the case of Kampong Brunei the high spleen rate seems to be connected with the proximity of this extensive swamp, which is only about one mile distant.

During the examination of these children one was naturally led to examine them for evidence of other diseases than malaria, but except for one child with tubercular dactylitis and cold abscesses over the tibia, none was found. I was informed by the natives that the death rate among the children was not high, and the birth rate, so far as it was possible to judge from a visit to the villages, did not appear low. The ages of these children ranged from 6 months to 14 years.

Six miles in a northerly direction from Membakut and about one mile east of the railway the country is entirely different and consists of good high land. Here, situated on the Bangawan River, is Bangawan Village, and the spleen rate of the 69 children examined was only 1·42 per cent. Rubber Estate (B) is situated about two miles

further up the river and there is little malaria among the coolies, in spite of the fact that no prophylactic quinine is taken. The spleen rate of 321 coolies was 7·1 per cent.

Apart from the railway which extends from Jesselton to Melalap, a distance of some 100 miles along the coast, and a few rivers, there is no means of communication, and when writing of travelling from district to district, travelling by rail is meant. From Bangawan, travelling in a northerly direction for about 5 miles and then following the Kimanis River for a further three miles, one reaches Kimanis Village, where among the 52 children examined the spleen rate was found to be 11·53 per cent. The land here for the most part is high and there is no extensive area of swamp. The village is cleaner than is usually the case with native villages and the houses are better built, with wider intervals between them. The jungle in the neighbourhood is not dense and the village itself, with the exception of a few coconut trees, is fairly free of vegetation. Owing to arrangements kindly made for me by the District Officer, the native chief of the district accompanied me round the village and I went into most of the houses. I was informed that the inhabitants at one time had had among them a wasting disease with cough, but with the exception of one boy suffering from emphysema, cough and cyanosis, I found no evidence of tuberculosis. A few rice-fields surround the village.

A further two miles up the river is Rubber Estate (C), where the spleen rate of the 379 coolies was 11·87 per cent. Prophylactic quinine is given. Great care was exercised by the manager to enforce the use of mosquito nets among the coolies, and had this not been so the amount of malaria in the coolie force would have been much greater, for a good many of the lines were situated near a piece of swamp where I found Anophelines breeding. An interesting fact on this estate was that one coolie line built on rising ground in the middle of an extensive swamp, which had large trees growing in it, was, so long as the trees remained standing, infested with malaria, but as soon as the trees were felled, although little could be done to drain the swamp, the malaria stopped. It seems that one explanation possible was that the large trees helped to shield the adult mosquitos when they bred out and that the short undergrowth which remained (as the land was unsuitable for planting) did not afford the same protection.

This observation may also explain the well-known fact on rubber estates that so long as the trees remain small, the malaria rate is small, but as the trees get larger the malaria increases. This phenomenon is sometimes attributed to the mere growth of the trees in itself in some unknown way, but I do not know of any observation tending to show that the size of the rubber trees without the presence of water, either in the shape of pools or small hill streams, has been responsible for malaria.

Twelve miles further north is Papar Village, and in the Mill Hill Roman Catholic Mission there, among 37 children drawn from the village, the spleen rate was 13·5 per cent.

Although the houses are widely separated, this is the most populous district on the west coast of this part of Borneo and there is a large amount of rice-growing. The land is flat and high, with no extensive area of swamp. The jungle may be described as light and is nowhere dense. As is the common experience, cultivated rice-fields do not seem to be a danger in favouring malaria in this district. Not

until Rubber Estate (D) is reached, in a direction almost due east, about five miles distant, does the land become hilly with intervening swamps. Here the native population is small. The spleen rate of the 322 coolies examined on this estate was 25.4 per cent (prophylactic quinine). The spleen rate was taken in the early stage of the development of the estate when there was a good deal of malaria, but after the drainage of the flat land and swamps and careful selection of sites for coolie lines it very much decreased.

All the rubber estates with which this paper deals were young and two only were beginning to produce in 1913.

Without exception, in any jungle or swamp land on the borders of estates, where search has been made, Anopheline larvae have been found, most commonly those of *Anopheles kochi*; and as these particular larvae are found so frequently in association with other Anopheline larvae, a further search would probably reveal the presence of malaria-carrying species. As pointed out by Dr. Watson, of the Federated Malay States, the question of the proximity to estates of jungle or swamp is an important one from the point of view of the planter when sites have to be chosen for the erection of permanent buildings, and it is essential that all buildings to be used as habitations should be placed well within the planted area, where drainage is generally good and properly maintained.

In the experience of the writer no better example of this could be found than on Estate (A), where many of the coolies were housed within a few feet of the large Membakut swamp. Malaria was very prevalent, and in the season occurred almost as an epidemic. The number of cases coming from these lines was three times as many as those coming from lines situated on another part of the estate a long distance from jungle or swamp. From the foregoing account it will be seen that the spleen rate of an estate coolie force corresponds to some extent to the spleen rate of the neighbouring village, and the amount of malaria to the proximity of swamp-breeding malaria-carrying mosquitos.

My reason for going into a good deal of detail with regard to the general conditions of this small area of Borneo is that I believe this part of the world to be little known in medicine.

The following is a list of the species found, and under each I have mentioned as many points as to breeding grounds, habits and occurrence of malaria as I have been able to collect. In most cases the adults have been taken, but a good many specimens have been bred from larvae. No great attention was paid to the characters of the larvae, but a note was generally made as to the kind of water in which they were found and associated conditions. In every case the specimen has been either compared with the type, when obtainable, or with the original description.

The new species has been compared in tabular form with all the known species without spots on the wings, except the American forms. In order to facilitate reference all the synonyms of the other species have been mentioned.

A map and rough plan are appended. The map (Map III) shows the general distribution of the species along this strip of coast, and the rough plan (Map IV) shows the local distribution around estate (A).

It is somewhat noteworthy that eight out of the ten species identified should be found in such a circumscribed area, and this illustrates in a convenient way how an estate can be invaded by mosquitos when situated too near to jungle or swamp.

## LIST OF ANOPHELINES FOUND.

A.—With unspotted wings : *Anopheles brevipalpis* sp. nov.

B.—With spotted wings :

1.—With banded palps, *A. kochi*, *A. maculatus*, *A. leucosphyrus*, *A. punctulatus*, *A. ludlowi*.

2.—With tip of palps grey, *A. separatus*.

3.—With palps unbanded, *A. barbirostris*, *A. umbrosus*, *A. albotaeniatus*.

**Anopheles brevipalpis**, sp. nov.

A large mosquito, without spots on the wings ; anterior cross-vein midway between supernumerary and posterior cross-veins ; palps less than three-fourths of the proboscis ; abdomen with a shiny appearance above ; anterior legs of male with one large claw and one rudimentary, the former with one tooth. *Culex* position assumed at

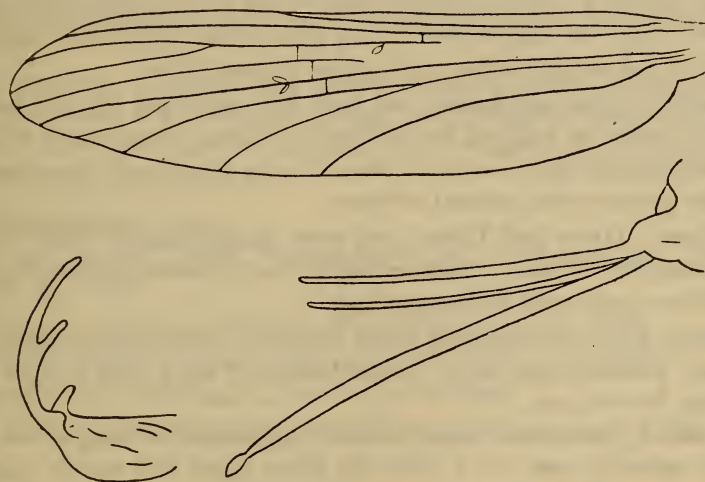


Fig. 1. *Anopheles brevipalpis*, Roper : wing, front claws of ♂, and proboscis and palpi of ♀.

rest. *Head* dark, scales uniform in structure, with free edge broad and finely serrated ; these scales light in colour in the middle, dark at the sides. Usual fine tuft of hairs projecting forwards between eyes ; fairly stout hairs curving forwards from behind and all round eyes. *Palps* dark, unbanded, rather less than three-quarters the length of the proboscis. *Proboscis* dark, unbanded. *Thorax* without ornamentation. *Scutum* slate-coloured and covered fairly thickly with hairs, a tuft of outstanding scales on pronotum. *Scutellum* slate-coloured with a few stout hairs. *Halteres* with light-coloured knob and dark stem. *Abdomen* : to the naked eye the

upper surface has a shiny appearance in recently killed specimens; covered everywhere with long yellow hairs, and entirely devoid of scales. *Legs* dark-scaled, without banding, long and slender. Anterior legs of male with one large and one rudimentary claw, the larger claw being about three times as long as the smaller, and having one tooth. *Coxae* and *trochanters* dark. *Wings* unspotted, lightly covered with scales, which are short and lanceolate. True anterior cross-vein midway between the so-called supernumerary cross-vein and the so-called posterior cross-vein, and all three separated by about the length of a cross-vein. *Length*, 5.5mm.

About 35 specimens of this species were found in the estate (A) hospital, a building situated 150 yards from the jungle and 200 yards from the Membakut swamp. Female specimens predominated. No larvae were found, and the hospital was the only building in which the species was taken. Five specimens were dissected, but none was found infected. January, June, April and December, 1913, were the months in which they were taken. The description is based on four females and two males.

The types have been deposited in the British Museum.

The other Old World *Anopheles* which have unspotted wings may be distinguished from *A. brevipalpis* by the following characters:—

*A. bifurcatus* has the free edge of the head scales distinctly forked; palps nearly as long as the proboscis; abdomen slatey brown; legs shorter and thicker, the anterior tarsi of ♂ with only one simple claw; wing scales long, lanceolate; anterior cross-vein internal to the supernumerary and posterior cross-veins.

*A. barianensis*, James and Liston, has both flat scales and upright forked scales on the head; palps as long as the proboscis; thorax ornamented with scaling; coxae and trochanters light; anterior cross-vein in a line with the supernumerary cross-vein, the posterior one internal to these.

*A. culiciformis*, James and Liston, has some spindle-shaped scales on the head and no projecting tuft of hairs; palps as long as the proboscis; anterior legs of ♂ with one simple claw; cross-veins almost in a line.

*A. algeriensis*, Theo., has the head scales distinctly forked; palps nearly as long as the proboscis; abdomen not shiny; costal margin of wing with a slight dip in the centre; length 3.8–4.5 mm.

*A. immaculatus*, Theo., head scales forked; palpi almost as long as the proboscis; legs banded; anterior tarsi of ♂ with the claws equal and simple; anterior and supernumerary cross-veins in a line, posterior one internal to these by three times its length.

*A. aitkeni*, James and Theo.; head with narrow forked and spindle-shaped scales, and no tuft of hairs; palps as long as the proboscis; anterior cross-vein external to the supernumerary and posterior cross-veins.

#### **Anopheles kochi**, Dön.

*Anopheles kochii*, Dönitz, Insectenbörse, Jan. 1901, p. 1, and Zeits. Hyg. u. Infekt. Krank., 1902, p.67.

*Christophersia halli*, James, Rec. Ind. Mus., 1910.

This is by far the commonest Anopheline found in the district. Specimens were bred out from the large Membakut swamp, swampy land near estate (C), a small

sago swamp at Bangawan, and from the jungle on the borders of estate (D). At different times adults were taken in the houses on estate (A) close to the swamp, and in one house on estate (D), though the numbers were never great. No definite outbreak of malaria could be ascribed to the presence of this mosquito, but *Anopheles barbirostris* and *Culex mimeticus* were often found breeding in the same pools. Larvae were found all the year round, being most abundant between May and October. When found alone, the larvae of *Anopheles kochi* seem to prefer small collections of water without vegetation, most commonly those present in the hoof-marks of cattle. Eight specimens were dissected, but no malarial parasites were found. In those bred from larvae, and also in the captured adults, females always predominated.

#### **Anopheles maculatus**, Theo.

*Anopheles maculata*, Theobald, Monogr. Culicid. i, p. 171, 1901.

*Nyssorhynchus maculatus*, Theobald, *op. cit.*, iii, p. 96, 1903.

*Nyssorhynchus willmori*, James, in Theobald, *op. cit.*, iii, p. 100, 1903.

*Neocellia dudgeoni*, Theobald, *op. cit.*, iv, p. 113, 1907.

Only three specimens of this mosquito were bred from larvae, all being males. The larvae were found in the same pool and at the same time as those of *Anopheles leucosphyrus* (Oct. 1913), near the small hill stream on the borders of estate (A). The water was clear, and although close to the stream, had no direct communication with it.

In view of the work of Stanton and Watson in the Federated Malay States, which shows that this species is a carrier of malaria, the finding of it in Borneo is of some importance to the rubber estates there, as many of them have hill streams favourable to the breeding of this mosquito.

#### **Anopheles leucosphyrus**, Dön.

*Anopheles leucosphyrus*, Dönitz, Insectenbörse, Jan. 1901, and Zeits. Hyg. Infekt. Krank., p. 56, 1902.

*Myzomia elegans*, James, in Theobald, Mon. Culic., iii, p. 51, 1903.

*Anopheles* "*leucophyrus*," James, Monog. Anoph. India, p. 82, 1904.

*Pyretophorus elegans*, Theobald, *op. cit.*, iv, p. 77, 1907.

*Myzomia* "*leucophyrus*," Leicester, Stud. Inst. Med. Research, F.M.S., iii, p. 28, 1908.

*Neomyzomia elegans*, James, in Theobald, *op. cit.*, v, p. 30, 1910.

The Borneo specimens are identical with Dönitz' original description.

This species was first found on the outside of a coolie line on estate (A), situated about 150 yards from the swamp, in July 1913. I was led to examine this line carefully on account of the occurrence of many cases of malaria there, and two days later specimens of this mosquito were taken. From July until the end of November specimens were constantly found in the nets of the coolies in the early morning. These were all gorged with blood and it was difficult to find a specimen which had not recently fed on a coolie. During these months cases of malaria were constantly coming from this line, as many as six and eight in a day. On one occasion one specimen of *Anopheles umbrosus* was taken. Many of these cases I looked upon as relapses,

but many also were men who had not been in hospital for malaria for over a year, and I felt justified for this reason in looking upon them as fresh infections. During the months of July, August and September, 1913, there were in all 62 cases, 33 of which were relapses and 29 fresh infections. In all the cases a search was made for the parasite, which was found in the majority, in spite of prophylactic quinine having been given daily. The actual figures for the fresh infections were as follows:—

Benign tertian parasites alone	..	..	13
Subtertian alone	..	..	3
Benign tertian with subtertian	..	..	2
No parasites found	..	..	11

The relapses were most persistent, in spite of daily quinine, after efficient treatment in hospital for a varying period of ten to fourteen days.

About 50 specimens were taken in all; females predominating. In October 1913 many cases of malaria occurred among the coolies on estate (A) who were working at a dam in the jungle on the borders of the estate. Among these cases again there were many relapses, but fresh cases also occurred. It must be mentioned that coolies who had recently been in hospital with malaria were working with coolies who had not been in hospital for malaria for over a year. A search was made in the neighbourhood of the dam for the breeding places of Anophelines and in a pool made in excavating clay about 150 larvae were found, which, after breeding out, proved to be *Anopheles leucosphyrus* and three specimens of *Anopheles maculatus*.

It was along the borders of this stream that the one specimen of *Anopheles umbrosus* was taken, as mentioned later under that species. At this time no *umbrosus* was found and although a prolonged search was made for larvae none were discovered in the stream.

*Anopheles leucosphyrus* seems to breed either in clean or dirty water, and larvae were found in swamp water with much scum on the surface, near the line previously mentioned, as well as in clean pools and in old cement barrels.

Seventeen specimens were dissected, but in only one instance was it possible to dissect the stomach, as in the other cases this organ was full of blood.\* The salivary glands were dissected in the other mosquitos in the hope that sporozoites, the result of a previous meal of infected blood, might be found, but none were discovered. Although from the facts recorded no definite conclusion can be drawn as to the malaria-carrying powers of this species, I think the evidence is suggestive.

#### **Anopheles punctulatus, Dön.**

*Anopheles punctulatus*, Dönitz, Insectenbörse, Jan. 1901, and Zeits. Hyg. Infectk. Krank., p. 57, 1902.

*Anopheles punctulatus*, Theobald, Mon. Cul. i, p. 175, 1901.

*Myzomyia tessellatum*, Theobald, *op. cit.*, i, p. 175, 1901, and iii, p. 55, 1903.

*Nyssomyzomyia punctulata*, James and Liston, Anopheline Mosquitos of India, 2nd ed., p. 104, 1911.

The Borneo specimens correspond with those labelled *A. tessellatus* in the British Museum in having four white bands (including the tip) on the palps, and not five as

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\* Many attempts were made to keep the insects alive until the blood was digested, but they all died.



in *punctulatus*.\* The banding of the palps seems to be the only difference between these two mosquitos ; in *punctulatus* the arrangement of the bands from tip to base is : white tip, black band, broad white band, black band, narrow white band, black band, narrow white band, broad black band, narrow white band, rest black ; in *tessellatus* the bands are : white tip, black band, broad white band, black band, broad white band, broad black band, narrow white band, rest black.

This species was found inhabiting the estate (A) hospital and one of the houses near the Membakut swamp. About 30 specimens were taken, but no larvae were found. The time of capture was April, May and July, 1913, females predominating.

#### **Anopheles ludlowi**, Theo.

*Myzomia ludlowi*, Theobald, *op. cit.*, iii, p. 42, 1903.

*Nyssomyzomia ludlowi*, James and Liston, *op. cit.*, p. 101, 1911.

Two specimens only (both females) were found ; one in a coolie line on a coconut estate at Kuala Lama, about six miles west of Membakut, in December 1912 ; and the other in one of the houses on estate (D) at Papar, in April 1913.

Sixteen cases of subtertian malaria had been admitted from the line in question and this species was the only one observed in the neighbourhood. No larvae were found.

#### **Anopheles separatus**, Leic.

*Anopheles separatus*, Leicester, Stud. Inst. Med. Research, F.M.S., iii, pt.3, p.36, 1908.

A careful comparison of ten females and two males with Leicester's types in the British Museum makes it clear that the specimens taken in Borneo belong to the same species. The points I would emphasise as being very constant and sufficiently differentiating it from the species it most resembles, namely *A. sinensis* and *A. umbrosus*, are as follows : the palps have dirty grey tips ; in the wings the middle spot always extends on to the first longitudinal vein ; yellow spot on first longitudinal vein always confined to this at the junction of inner third with outer two-thirds of wing ; yellow spot on fringe between lower branch of second longitudinal vein and third longitudinal vein ; predominance of light scales ; absence of apical ventral tuft on the abdomen. I should add that in two out of the ten females there was in the palps a faint suggestion in one case of one additional ring, and in the other of two additional rings. In the male the expanded portion of the palp is dirty grey, with a light brown thin band in the centre.† In spite of these small deviations the other characters were constant.

Adult specimens were taken in the houses on estate (A) and in the estate (A) hospital ; one specimen came from the Rest House in Jesselton. It is not a common species and only about twenty specimens were obtained, females predominating. One female was bred from a larva found in the Membakut swamp. No note was made as to the characters of the larva.

\* [According to Mr. F. W. Edwards, *A. tessellatus* is a purely Oriental species, it being represented in the Australasian region by *A. punctulatus* (Bull. Ent. Res. iv, 1913, p. 221.—Ed.)

† This point shows in Leicester's types, but is not mentioned in his original description.

**Anopheles barbirostris**, Wulp.

*Myzorhynchus barbirostris*, van der Wulp, Theobald, *op. cit.*, iii, p. 86, 1903.

The specimens taken in Borneo correspond with Theobald's quotation (*op. cit.* i, p. 146) of van der Wulp's description. The white scales described by Stanton (Journ. London School Trop. Med., ii, pt. 1) as being present on the ventral surface of the abdomen of the female are also found on the male in all Bornean individuals examined.

Many specimens of this species were found in the buildings on estate (A), and many were also bred from larvae found in the swamp and in the estate drains near the swamp. These larvae were found from February, 1913, until December, 1913, but the majority of the adults were taken between May and October. Females always predominated, both in those bred from larvae and in captured adults. The larvae had the outer anterior clypeal hair thickly branched, as described by Stanton. The pools in which the larvae were found generally consisted of swamp water without scum. Three specimens were dissected for malarial parasites, but none were found.

**Anopheles umbrosus**, Theo.

*Myzorhynchus umbrosus*, Theobald, *op. cit.*, iii, p. 87, 1903

The Borneo specimens agree in every detail with Theobald's description, except that no note is made as to the variation of the wing spots. About 400 specimens were obtained, mostly from the estate (A) hospital, and females very much predominated. In the neighbourhood of Membakut it was by far the commonest Anopheline, and as many as 90 have been taken in the hospital in one day. It was also a frequent visitor in other houses situated near the swamp or jungle. I took one specimen which settled on me in the open near a small hill stream during the day-time. One other specimen was taken in the net of a coolie on estate (C). Although a large number of larvae were bred out in the search for this species, its larva was not found. The constant presence of this mosquito in the hospital could not be accounted for, except by the proximity of the jungle, and as no larvae could be found in the swamp or jungle some particular breeding place was suspected among the hospital buildings, but a careful investigation revealed nothing. Prolonged search was also made in the hill streams, of which there were several near the hospital, but no larvae were found.

As regards the time of year during which most of the specimens were captured, it was found that the numbers gradually increased from December, 1912, to a maximum in June, 1913, when the numbers diminished again to the following December. From May to October is the most malarial season in this district.

Of 130 specimens dissected only one captured individual was found with the sporozoites of malaria.

This species resembles *Anopheles albotaeniatus* very closely in every particular, except as to the hind tarsi. The point mentioned by Colonel Alcock in his paper, "Synopsis of the Anopheline Mosquitos of Africa and of the Oriental Region" (Journ. London School Trop. Med., ii, pt. 3) with regard to the legs being brown, is a very noticeable one. This can be seen readily with the naked eye and is more obvious on the under surface, being most marked in fresh specimens. It is, I think, due to the lighter scaling on the under surface.

As this mosquito was so plentiful, an opportunity was taken of studying the variability of the species. In this way 79 specimens were examined. The variations were most marked with regard to size of the insect and spotting of the wings.

Three distinct sizes could be made out, a small, intermediate and large; the smallest measured 3.75 mm. and the largest 5.5 mm. Except for the markings on the wings of the largest variety (referred to later), there was no noticeable difference between these varieties.

From the table shown below it will be seen that 65.8 per cent. showed two costal spots on the wings, although in 17 of these the middle spot was faint. In only 11, or 13.9 per cent., was there a single spot at the end of the wing. The fringe spot is most commonly found at the end of the third longitudinal vein, namely in 88.8 per cent. Not only is the variation noticeable in different specimens, but also in the two wings of the same specimen. In the case of the largest variety the end spot is much larger and is divided into two by a few dark scales.

The most constant characters of the wings are therefore:—Wings with two costal spots, one in the middle of the costa and one at the end of the costa; one fringe spot opposite the third longitudinal vein.

*Table showing variability of wing spots of Anopheles umbrosus.*  
*Costal Spots (No. examined, 79).*

With two costal spots well marked in both wings . . . . .	35
With end spot present in both wings and middle spot faint in both	17
With end spot and no middle spot in both wings . . . . .	11
With end spot present in both and middle spot present in one wing and absent in the other . . . . .	8
With end spot present in both, and middle spot faint in one wing and absent in the other . . . . .	5
With end spot present in both, and middle spot marked in one wing and faint in the other . . . . .	3

*Fringe Spot (No. examined, 72).*

With spot opposite third longitudinal vein . . . . .	64
With spot opposite lower branch of second longitudinal vein . .	4
With spot between lower branch of second longitudinal vein and third longitudinal vein . . . . .	4

### **Anopheles albotaeniatus**, Theo.

*Myzorhynchus albotaeniatus*, Theobald, *op. cit.*, iii, p. 88, 1903.

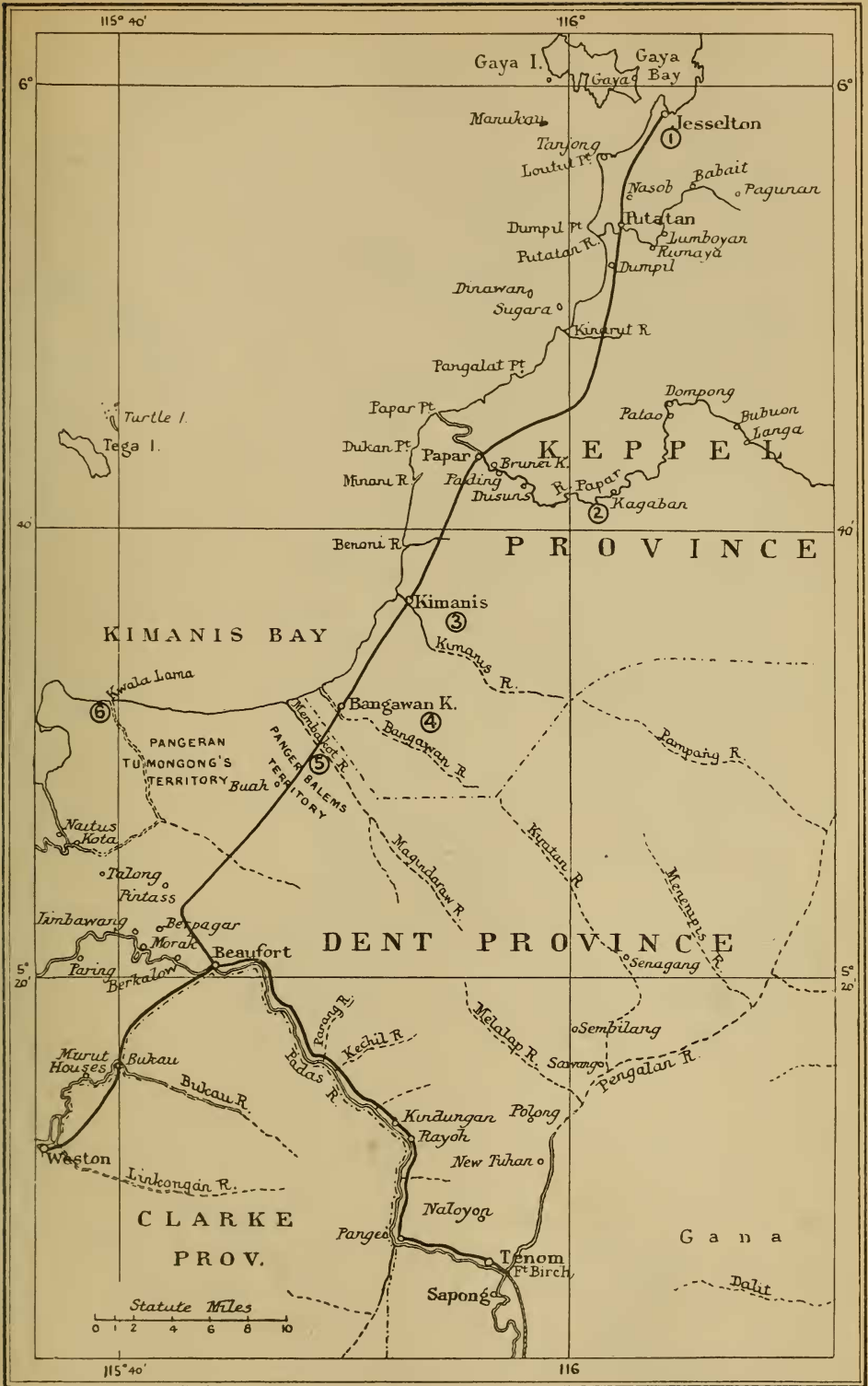
Only three specimens of this species were found, all of which correspond with Theobald's description. One was taken in 1912 and the two others in April 1913. They were all females and were captured in the estate (A) hospital. No larvae were obtained.

In conclusion, I wish to acknowledge my indebtedness to Lt.-Colonel A. Alcock, F.R.S., C.I.E., for much valuable advice and assistance in the preparation of this paper and to the authorities of the British Museum for allowing me to examine the specimens in the national collection.

EXPLANATION OF REFERENCE FIGURES IN MAP III.

The numbers indicate the occurrence of the following species :—

- (1) *Anopheles separatus*.
- (2) „ *kochi* ; *A. ludlowi*.
- (3) „ *kochi* ; *A. umbrosus*.
- (4) „ *kochi*.
- (5) „ *kochi* ; *A. brevipalpis* ; *Anopheles umbrosus* ; *Anopheles bar-*  
*birostris* ; *Anopheles punctulatus* ; *Anopheles leucosphyrus* ;  
*Anopheles albotaeniatus* ; *Anopheles separatus*.



SKETCH-MAP OF THE WESTERN COAST OF BRITISH NORTH BORNEO.

